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Review

When range of motion is not enough: Towards an evidence-based approach to medico-legal reporting in whiplash injury

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ABSTRACT

Whiplash injury medico-legal reporting has traditionally been focused upon identifying restrictions in range of motion and identifying the presence of tender areas in the cervical spine in an effort both to diagnose the condition and to offer a prognosis. There have been considerable advances in this field over the last decade however that calls into question such a diminutive approach. This paper reviews the contemporary evidence base for the medico-legal assessment of whiplash injury and identifies a body of literature that strongly implicates a Claimant's physiological and psychological stress response as a key medico-legal marker in predicting prognosis following whiplash injury.

1. Introduction

Variously described as a 'medico-legal illusion'[1] and a 'man-made illness'[2] whiplash remains a controversial topic, with nearly 500,000 claims per annum in the UK alone in 2012–13 and an estimated annual cost to the UK of £3 billion.[3] Costs in the United States have been described as, 'staggering' at US$230 billion per annum.[4]

A standard whiplash injury medico-legal report often consists of a review of the Claimant's history, an examination of the range of motion and the presence of tender areas in the neck region. In the last few years however there has been considerable progress in this field that challenges this approach. Also, whilst the *diagnostic* challenges that exist for the medical expert have been well documented[5] there have been few contributions to the medico-legal literature regarding *prognostication* following whiplash injury. This is somewhat surprising when one considers that whiplash appears to be characterised by a slow recovery: at one year post-injury 50%[6]; at two to three years 20%[7]; and at four years eight percent will still be experiencing symptoms, a figure the latter author termed a, 'significant minority'.[8] Some authors have presented evidence suggesting that most recovery, if it occurs, takes place within the initial three months following the injury, with a plateau in recovery after this time.[9] These data exist in stark contrast to recent evidence from the UK that reported only six percent of whiplash injury Claimants were given a prognosis greater than 12 months.[5]

That whiplash injury can lead to longer term problems is also supported by retrospective studies: sustaining a whiplash injury is the strongest aetiological risk factor for neck pain, tripling the chances of future neck pain long after litigation has completed.[10] Amongst those at high risk of poor recovery, attempts to prevent transition from the acute to the chronic stage of the condition[11–13] or reverse chronicity once established[14,15] are largely unsuccessful.

The aim of this paper is to review the evidence base for the medico-legal assessment of whiplash injury. The emphasis will be placed upon identifying those Claimants at risk of poor recovery by reviewing the subjective assessment of whiplash injury (crash related factors, pain, disability, dizziness and psychological disturbance) and those 'objective' tests (probably more accurately described as 'psychophysical' tests) that can be performed easily in the medico-legal setting. As the term 'whiplash' as a diagnosis is non-descriptive, in this paper 'whiplash injury' refers both to the symptoms that arise following the whiplash mechanism of injury *and* the mechanism of injury itself.

2. Prognosis: can knowledge of pathology help?

There exist a plethora of animal, human cadaver and computer simulation studies that have identified the cervical spine facet joints,[16,17] intervertebral discs and ligaments,[18–20] muscles,[21–23] dorsal root ganglia[24,25] and vertebral artery[26,27] as being susceptible to injury during the whiplash mechanism, with the majority of

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the experimental evidence implicating the facet joint – and most probably the facet joint *capsule* – as a primary cause of symptoms following whiplash injury. Clinical studies demonstrating significant pain relief in chronic neck pain cohorts following nerve blocks or radiofrequency neurotomy lend support to this view.[28] The *experimental* evidence is compelling for facet joint injury following whiplash.

In vivo studies of pathology following whiplash injury are historically poorly represented in the literature,[29] and they have not been without their critics.[30] Freeman and colleagues[31] demonstrated in a high quality study 'substantial neuroradiographic differences' in the frequency of cerebellar tonsillar ectopia (CTE or Chiari malformation) between 1195 subjects with neck pain, with and without a recent history of motor vehicle related crash trauma. Indeed the authors concluded by criticising prior research on psychosocial causes of chronic pain following whiplash for failing to account for a possible neuropathologic basis for the symptoms. A recent investigation within 48 h of the injury and using a turbo STIR sequence on a sample of subjects – a proportion demonstrating no objective signs (i.e. Quebec Grade I) – documented occult fractures and bone contusions of vertebral bodies and strains, tears, haematomas and perimuscular fluid in muscle.[32] Muscle damage has also been demonstrated in the acute stage of injury using diagnostic ultrasound scanning[33] and there has been anecdotal surgical evidence of muscle rupture, facet joint capsule rupture and ligament sprain.[34]

In the absence of CTE/Chiari-type symptoms[1] then, the majority of Claimants' will have no precise injury that can be linked to the symptoms, using currently available technology. Indeed, the majority of the injuries arising from cadaver and animal models cannot be identified by clinically available diagnostic modalities. The prospect of imaging devices with higher resolution may provide a link between tissue injury and outcome in the future, but for the present time we must rely on the clinical history and examination to provide a window upon the Claimant's prognosis.

3. Prognosis: history and clinical examination

3.1. Pre-injury status

The prognostic role of pre-injury neck pain remains unclear[6] and those reviews that have demonstrated an effect for the presence of pre-injury neck pain have described it as, 'small but significant'.[35] The effect size for history of headache suggests no significant risk of persistent problems.[35] Carroll et al.[6] found, 'no scientifically admissible' studies which addressed the impact of disc degeneration on recovery from whiplash injury and a more recent one year prospective study demonstrated that pre-existing degeneration on magnetic resonance imaging (MRI) was not associated with prognosis.[36]

3.2. Demographic variables

The evidence varies on the role of age and gender as a prognostic factor for recovery following whiplash injury, however in those reviews that have identified older age and gender as prognostic for poor recovery, the effects are negligible to modest,[6,35] with the prognosis for females being slightly worse (female OR = 1.64).[35] Having less than post-secondary education has been associated with poor prognosis.[35] Additionally the relationship between compensation-related factors, symptoms and outcome is currently unclear[37] due in part to what Spearing[38] has termed 'reverse causation bias' i.e. the likelihood that poor health influences the decision to pursue compensation.

3.3. Crash related factors

Crash related factors include collision direction, use and type of head restraints, speed of impact, awareness of collision, position in seat and whether the person's head was turned at the time of the accident. Whilst experimental data has suggested that having a rotated neck position at the time of impact *doubles* the strain through the facet capsule,[39,40] clinically orientated systematic reviews have identified few crash related factors that have predictive utility.

Carroll et al.[6] concluded there was no association between crash related factors and outcome, except for a modest effect for those injured while driving a vehicle fitted with a tow bar having a poorer prognosis. Not wearing a seat belt at the time of the collision appears to lead to a two-fold increase in the risk of developing whiplash related pain and disability at 12 month follow up.[41] Sterling makes the interesting point that this factor ('I was not wearing my seatbelt') is likely to be under reported in jurisdictions where compulsory seat belt use is legislated, so the risk associated with this factor may be even higher.[4] More recently Walton et al.[35] utilising rigorous inclusion criteria in a systematic review and meta-analysis concluded that parameters of the collision show no predictive ability in identifying risk of poor outcome. Variables with strong evidence of *no* effect include, 'unprepared for collision,' no head restraint in use and vehicle stationary when hit.[41]

In an attempt to explain the lack of evidence, some authors have noted that crash related factors rely heavily upon the self-report of the Claimant making them highly susceptible to both recall bias and desirability bias (secondary motive influencing reports).[35]

3.4. Presenting signs and symptoms

Initial post injury pain intensity, number and severity of injury related symptoms and the presence of radicular signs or symptoms appear to be substantial predictors of recovery.[6,35,41] Walton et al.[35] recently found a six-fold increase in risk of persistent pain or disability at follow up in those complaining of high neck pain intensity (defined as a score of six out of ten on a Visual Analogue Scale or VAS). Self-reported headache at inception is associated with a significant increase in the risk of reporting persistent problems at follow-up and reports of low back pain also demonstrate a small but significant risk for persistent problems.[35] In one cohort, 30% of acute whiplash patients presented with a *neuropathic* pain component, as measured by the Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS)[42]; a score of $\geq$12 on this scale predicted poor recovery.

The most commonly used measure of disability in whiplash is the Neck Disability Index (NDI)[43] The NDI is a 10-item questionnaire that allows scoring of activities of daily living pertaining to the neck region from 0 to 5. The scores are summed to give a total of 50 or multiplied by 2 to give a percentage score. Scores on this instrument are predictive of poor recovery: 30% or higher in one meta-analysis.[35] In a more recent study designed to establish a clinical prediction rule for use following whiplash injury a score of $\geq$40% predicted chronic moderate/severe disability with a score $\leq$32% predicting recovery.[44] The latter study also included age and a measure of post-traumatic stress response in the clinical prediction rule and this is discussed below.

Dizziness appears to be a common yet overlooked symptom following whiplash injury. In one cohort of whiplash injuries as

[1] History of whiplash mechanism of injury and persisting suboccipital headache in combination with headache worsened by cough or bilateral sensory or motor deficits in the upper extremities.[31]

many as 75% of subjects complained of dizziness.[45] The unsteadiness that can occur following whiplash injury is hypothesised to arise from injury and disruption to the deep muscle spindles of the cervical spine and the mechanoreceptors of the facet joint capsule. One theory suggests that distortion of the afferent signals from the muscle spindles leads to a conflict of information in the dense anatomical reflex connections between the muscle spindles, the eyes (cervico-ocular reflex) and the vestibular system (vestibulo-ocular reflex).[46] Indeed, there is increasing objective evidence of disturbances to smooth pursuit eye movement control, proprioception of the head and neck, and postural instability following whiplash injury,[47–49] however these sensorimotor signs and symptoms, including smooth pursuit eye movement tests, do not appear to be useful as predictive factors following whiplash injury.[50]

Cervical range of motion has been found to have no significant effect on recovery[51] with a recent meta-analysis confirming these findings,[41] despite its continued use as the sole 'objective' prognostic measure in whiplash injury medico-legal reporting.

Widespread sensory change has been identified in a sub-group of 20% of whiplash injured subjects.[7] This manifests as reduced pressure pain thresholds ('PPT' the threshold at which pressure becomes pain) at areas removed from the site of injury and a heightened sensitivity to a cold stimulus, both indicative of augmented central pain processing that has also been identified in fibromyalgia.

In one systematic review cold hyperalgesia was found to be associated with a poorer outcome.[51] Walton et al.[52] have demonstrated that PPT's at a site over the anterior shin (tibialis anterior muscle) significantly predicted the variance in short term outcome in individuals with acute whiplash injury. The authors concluded that PPT's represent a, 'promising addition' to the clinical assessment of traumatic neck pain.

3.5. Presenting signs and symptoms – psychological impairment

Carroll et al.[6] found that psychological factors are prognostic of recovery in whiplash injury with passive coping, helplessness, fear of movement, catastrophising and anxiety all predicting slower recovery. Catastrophising appears to have a significant effect on recovery[41] with negative expectancies, increased attention to pain sensations ('rumination'), less effective coping strategies (eg activity reduction) and endogenous opioid dysregulation all possible pathways to poor outcome.[53] Fear of movement also appears to contribute to the relationship between pain and disability post whiplash injury.[54] Depressive symptoms appear to play no role in outcome.[41]

Williamson et al.'s systematic review of psychological risk factors,[55] concluded that decreased self-efficacy ('confidence to perform activities despite pain') and a post-traumatic stress reaction are predictive of poor recovery but identified no other prognostic psychological factors. Sterling et al.[56] have suggested a score of ≥26 on the Impact of Event Scale questionnaire (IES), a measure of post-traumatic reaction, indicates risk of poor recovery. In one study utilising a group based trajectory model at three months post whiplash, 22% of participants met the criteria for a probable PTSD diagnosis with this percentage decreasing to 17% at 12 months.[9] Sterling has noted that these data are surprisingly similar to that documented for people with more severe traumatic injury that requires hospitalisation or admission to intensive care.[4]

In a prospective cohort followed up for three years, age, NDI score, cold hyperalgesia and post-traumatic stress symptoms measured at 4 weeks had a classification rate of 60% for this group of non-recovered 'high pain and disability' subjects at 3 years.[7] In the latter study 'at risk' subjects presented with high levels of pain, high levels of disability, an unresolved post-traumatic stress response and increased sensitivity to both mechanical pressure at areas removed from the site of injury (reduced pressure pain threshold) and cold stimuli (cold hyperalgesia). This group has been described as having, 'complex whiplash.'[56]

Table 1
Risk factors for poor recovery following whiplash injury.

Less than post-secondary education
Failure to wear a seatbelt
Post injury pain ≥6/10
Number and severity of injury related symptoms
Presence of radicular signs and symptoms
Post injury headache
Post injury low back pain
Neuropathic pain
Neck Disability Index score ≥40%
Post traumatic stress symptoms
Catastrophising
Reduced pressure pain threshold at shin
Cervical spine cold hyperalgesia

As discussed above, a recent study has derived a clinical prediction rule for identifying recovery and non-recovery that includes age, the NDI Score and the hyper-arousal subscale of the Post-traumatic Diagnostic Scale (PDS): an individual who meets the following three criteria is likely to develop moderate/severe disability: NDI ≥40%, age ≥35 years and ≥6 on the hyper-arousal subscale of the PDS.[44,57] Hyper-arousal symptoms include feelings of irritability, being easily startled and increased sweating. Conversely, an individual who meets the following two criteria is likely to fully recover: NDI ≤32% and age ≤35 years.

3.6. Screening for risk of poor recovery

The main factors that appear to be strongly predictive of poor recovery following whiplash injury are shown in Table 1. The subjective self-report aspects (eg pain levels, sites of injury etc.) are easily assessed in the medico-legal setting. Assessing disability levels and screening for neuropathic pain and a post-traumatic stress reaction requires the use of standardised, validated questionnaires (Table 2). An interactive NDI that sums the total automatically for the expert is available on-line (www.orthoscores.com) and can be completed relatively quickly 'in-house' during the examination.

In terms of assessing pressure pain thresholds, a relatively inexpensive hand held device an, 'algometer' that reliably quantifies tenderness by measuring the precise force required to produce the first sensation of pain can be utilised. There has been normative data published in acute and sub-acute whiplash patients[58] for the algometer and whilst local, mechanical hyperalgesia is a common finding in the majority of neck pain patients, increased tenderness at a location *removed* from the area of trauma – as stated above, the shin is commonly used in the research setting – strongly suggests the presence of widespread mechanical hyperalgesia.

Table 2
Identifying poor outcome following whiplash injury.

Questionnaires	Description	Comments
Neck Disability Index[43]	Disability measure	≥40% suggests increased risk of poor recovery
S-LANSS[60]	Neuropathic pain measure	≥12 suggests increased risk of poor recovery
Impact of Event Scale[61]	Post Traumatic Stress Reaction Screen	≥26 more than 6 weeks post injury suggests increased risk of poor recovery.

A Thermoroller, cooled to 15 °C can be used to examine for signs of cold hyperalgesia but recent work has suggested a simpler method that involves applying an ice pack to the posterior aspect of the cervical spine for 10 s[59] which, if the patient rates the resulting sensation as painful and scores ≥5/10 on the VAS, strongly suggests the presence of cold hyperalgesia. If the patient scores <1/10 on the VAS, this strongly suggests the absence of cold hyperalgesia.

A logical evidence based pathway for screening for poor recovery would be: if NDI ≥40% then screen for posttraumatic stress response and widespread hyperalgesia using PPT's at shin (algometer) and cold hyperalgesia at the neck (thermoroller/ice pack).

4. Conclusion

There is a burgeoning body of literature that strongly implicates a Claimant's physiological and psychological stress response as a key driver in persistent symptoms following whiplash injury. The tools that are required to identify the 'complex whiplash' Claimant are portable, inexpensive and as a result, they are well suited to the expert witness's medico-legal practice.

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Conflict of interest

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Posttraumatic Diagnostic Scale available from http://www.pearsonassessments.com (15 October 2013, date last accessed).

Contact author for public domain questionnaires.

Handheld digital algometer FDX-25; Wagner Instruments, Greenwich, CT.

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